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Variation in Habitat Utilization and Population Size Estimation of the African Grey Parrots in the Djangui Forest Clearing, Lobéké National Park, Cameroon

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Abstract

Due to the problems (pet trade, habitat destruction, and degradation) faced by the grey parrots (*Psittacus erithacus*), which seem to persist despite conservation efforts, there is a need for long-term monitoring data on the parrot's population and factors that shape their behavior in the wild. The objectives of this article are to 1) examine the population size of grey parrots in the Djangui forest clearing of the Lobéké National Park; 2) examine the yearly, seasonal, and diurnal variations in the habitat utilization of the grey parrots. To do so, we used distance sampling from a fixed point and direct observation to monitor the grey parrots visiting the Djangui forest clearing. The hazard-rate model with a 2-order cosine adjustment showed an average of 2230.2 parrots visited the forest clearing. The Generalized Additive Model showed a yearly, seasonal, and diurnal drop in the abundance of parrots visiting the Djangui forest clearing, with more parrots arriving during the mid-wet season. It also showed that the landing pattern was influenced by the time of day and the weather. We also found interspecific relationships between the parrots and other species that visited the forest clearing. This study provides baseline data which could be used to implement conservation actions to better protect the grey parrots both in the Lobéké National Park and the Tri-National Area. We recommend further research on their movement patterns within the park and integration of local ecological knowledge.

Keywords

Habitat Utilization, Behavior, Grey Parrots, Population Size Estimate, Lobéké National Park

1. Introduction

Grey parrots (Psittacus erithacus), also described as “forest specialists” because they frequent the forest interior and are likely to disappear if the forest is modified to a certain extent, are among the most traded parrot species worldwide [1]-[6]. According to Blanco *et al.* (2018) and other research studies, the endangered species was once abundant in West and Central Africa, where they inhabit primary and secondary forests, wooded savanna, and montane forest [4] [7]-[9].

Over the years, there have been reports of population decline of 50% - 79% over three generations [10]. The decline in population has been associated with the capture for the pet trade and habitat loss or degradation [4] [5] [9] [11]. Since 1975, an estimated 1.22 million parrots have been exported in the international trade, without taking into consideration the parrots transported illegally and those that died during transportation [5] [12] [13]. According to BirdLife International (2017), during the late 1990s and 2000s, in Cameroon alone, there was a capture rate of approximately 100,000 parrots per year, and until 2016, the export quota was approximately 5000 [5] [10] [12].

Furthermore, grey parrots suffer from habitat loss and degradation as a result of timber exploitation, farming, and urbanization, which may lead to a lack of large trees for nesting cavities [3]-[5] [14]. In Africa, and in Cameroon specifically, most of the large trees preferred by the grey parrots, such as *Terminalia superba*, are the most exploited and exported species [4] [5] [14].

Cameroon’s Lobéké National Park, a UNESCO World Heritage Site, forms part of the Congo Basin Forest and remains one of the strongholds for grey parrot populations. The parrots constitute one of the umbrella species of the park alongside the western lowland gorilla (*Gorilla gorilla*) and the forest buffalo (*Syncerus caffer*). They travel over long distances daily to visit forest clearings (Djangui and Bolo) found within the park to feed on its mineral-rich soils as well as to socialize with one another [15] [16]. Unfortunately, they suffer from a high capture rate within these clearings despite the conservation efforts [15]-[18]. These forest clearings, also known as mineral, clay, and salt licks, possess minerals important for the parrot diet and ecology [9] [15]. Studies on neotropical parrots and grey parrots show that they carry out a practice known as geophagy, whereby the parrots intentionally feed on the mineral-rich soil to aid in digestion and/or act as an anti-poison against the poisonous fruits they consume [9] [19]-[21].

Despite reports of the high capture rate occurring within the park, existing literature estimating parrot population size and behavior dates back many years, and these observations did not take into consideration seasonality and other factors that influence parrot behaviors [15] [16]. Studies of parrot behavior within clearings show that it has been shaped by predation, competition, seasonality, and food availability, but few such studies exist [9] [20] [22]. It is easier to monitor parrot population and behavior within these sites because the openings present an opportunity to estimate parrot population size, see clearly what they are doing, and observe how they interact with conspecifics and other animal species [3] [9] [18].

Given the importance of this information in the protection and management of grey parrots, this study had two objectives: 1) Estimate the population size of the grey parrots in the Djangui forest clearing of the Lobéké National Park, and 2) Examine the yearly, seasonal, and diurnal variations in the habitat utilization of the grey parrots within this clearing.

2. Materials and Methods

2.1. Description of the Study Site

Lobéké National Park (hereafter referred to as LNP) is situated in southeast Cameroon between Latitude 2˚05' - 2˚30'N and Longitude 15˚33' - 16˚11'E and has a surface area of 217,854 ha (**Figure 1**). Administratively, the park is located in the Moloundou Sub-Division, and the Boumba and Ngoko Division in the Eastern region of Cameroon. It is situated northwest of the Congo Basin slopes and is part of the transboundary regional protected area network, including two other parks: the Dzanga-Ndoki National Park in the Central African Republic and the Nouabale-Ndoki National Park in Congo-Brazzaville [23] [24].

The habitat types found within the park include dense or mature primary forest, swampy forest, and grassland or lowland vegetation [24]. Within these different habitat types are mineral-rich forest clearings. The LNP has eight (8) forest clearings, namely: Djangui, Petit Savane, Bolo, Ngoa, Djembe, Djaloumbe, Ndangaye, and Samba. The vegetation within these clearings is dominated by grass species of the Cyperaceae, Poaceae, Fabaceae, Asteraceae, Acanthaceae, and Rubeaceae families [25]. The common trees found within the park around these clearings include *Ceiba pentandra, Terminalia superba, Triplochiton pterygote*, and *Phoenix reclinate*. Due to the abundant resources and mineral-rich soil of these clearings, they attract a wide variety of mammal and bird species, including Western lowland gorilla, forest elephant (*Loxodonta cyclotis*), forest buffalo, sitatunga (*Tragelaphus spekii*), and African green pigeons (*Treron calvus*).

The Park has an Equatorial climate with four seasons, namely: Big dry season (December to February), small rainy season (March to June), small dry season (July to August), and Big rainy season (September to November) [24] [26]. The mean annual rainfall ranges from 1500 to 1600 mm/year, with an average temperature of 25.4˚C and humidity ranging from a minimum of 60% to a maximum of 98% [23] [26].

The Park is surrounded by local communities with people from the Baka, Bantou, and Bawele ethnic groups, as well as immigrants of different ethnic groups from the Central African Republic and the Republic of Congo. There are also Forest Management Units (FMU) owned by logging concessions and hunting zones (both state- and community-owned). The main activities of the people surrounding the park include hunting, fishing, the collection of Non-Timber Forest Products (NTFPs), and farming. According to Tieguhong and Nkamgnia (2012), a majority of the people, especially the Baka, are highly dependent on forest resources, and there have been reports of parrot capturers within the forest clearings of the park and poachers since its existence [16] [17] [23].

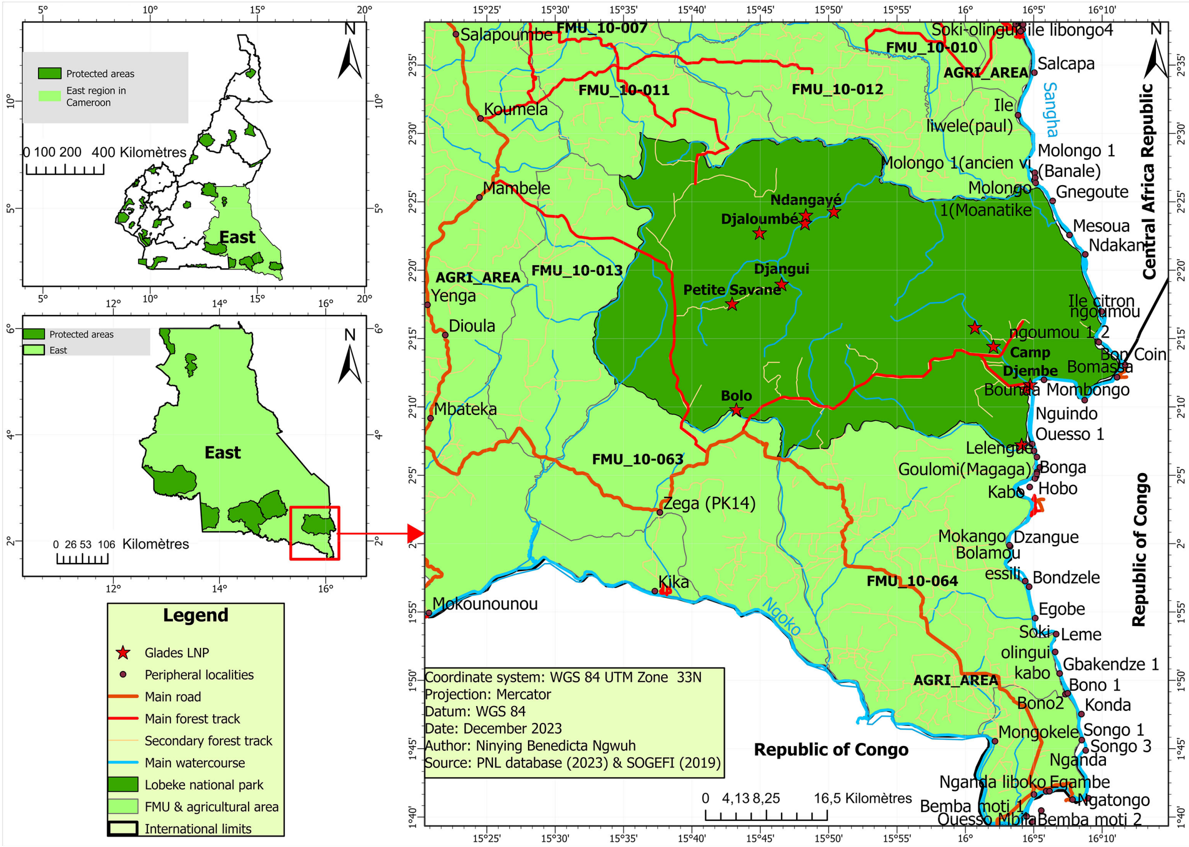

Figure 1. Map showing the location of the Lobéké National Park, its surrounding villages, and forest clearings.

2.2. Data Collection

Data collection took place between September 2022 and December 2024, after obtaining a research permit from the Ministry of Scientific Research and Innovation, and the Ministry of Forestry and Wildlife. We used the distance sampling method to conduct point counts from a fixed point (Mirador; a tall building at the center of the forest clearing used for observation) and to observe parrots' behavior. This method has been proven effective for estimating parrots' densities and observing their behaviors in many studies [9] [15] [16] [27]. We were unable to collect data every month, but prioritized collecting data during seasonal transitions (that is, the small and big rainy season and the small and big dry season).

Due to the dense vegetation structure of the Lobéké National Park and the cryptic behavior of the grey parrots, it was not feasible to establish multiple randomly placed points. Given the low visibility below the dense canopy, standard random point placements would have been ecologically unproductive. The selected mirador was strategically located within the Djangui forest clearing; its position maximizes detectability while minimizing observer disturbances. The use of a mirador aligns with established practices in tropical forest avian ecology, where fixed points have been effectively used for elusive and canopy-dwelling species [28].

Although random placement and full independence of detections were constrained, a valid detection function was still fitted using the distance data recorded from the mirador, as recommended by distance sampling protocols [29]. Additionally, the site was visited multiple times across multiple seasons and years, providing robust temporal coverage that helps offset this temporal limitation.

Point counts took place every morning from 06:00 AM after sunrise and ended when the last parrot left the forest clearing. We stationed two observers at different corners of the mirador approximately 10 m apart; these positions were maintained throughout the data collection period. They each recorded every single new parrot arrival within every ten-minute interval from 06:00 AM till about 10:00 AM, when the parrots started parading back and forth in the clearing (we did this to avoid the risk of double counting). While we attempted to minimize biases by eliminating double-counting, we still observed avoidance behavior whereby the parrots turned to avoid perching on trees or landing in areas close to the mirador due to the presence of the counting team, which is a potential bias to the findings. The data set was used to calculate the encounter rate measured as the number of flocks encountered per unit effort included. We counted the parrots upon arrival because they arrived in smaller groups as opposed to when they were perched or landed to feed. It is worth mentioning that even though observations ended at noon, we stayed at the forest clearing until 15:00 PM after noon to see if the parrots came back to the clearing.

We also recorded the arrival time of the first parrot(s) and other bird and mammal species that visited the forest clearing. The activities carried out by the parrots within and around the forest clearing, and their interactions with other bird species and mammal species were observed. Furthermore, we recorded the time when the first parrot landed, the landing site, when the first parrot left the landing site, and when the last parrot left the forest clearing. Additionally, we recorded different plant species used by the parrots in and around the clearing. We took pictures of the herbs fed on by the parrots and areas of the soil where we saw beak marks indicating geophagy. Lastly, we noted observations of activities that disturbed the parrots within the forest clearing, for instance, human presence (poachers) and predators.

At the end of the counting session every day, we grouped the data collected by the observers to obtain the average number of parrots that visited the clearing each day. We took the upper values of the counts done every ten minutes and eliminated the other values. This was done in order to increase the accuracy of the counting method and the number of birds recorded, and to ensure that even the shy birds were counted and observed during the process.

2.3. Data analysis

2.3.1. Population Size Estimation

Four detection functions were fitted and tested using the "Distance" package of the R Programming Language, Version 4.1.0: half-normal and hazard-rate models with or without cosine adjustments. The detection functions were fitted, truncating observations at a maximum distance of 50 meters to enhance model robustness because the birds could be hiding in trees and to effectively include shy birds. The second-order cosine adjustment term was applied to smooth the detection function and improve its monotonicity. We incorporated flock size as a covariate into the model fitting process, since recordings in the field were based on flock size of parrots.

The sampling effort was quantified as the number of observer visits to the forest clearing, and the total number of observation hours was calculated by multiplying the total number of hours spent in the forest clearing per day with the total sampling effort at the end of the study. Among the competing models, we retained the hazard-rate (Hr) model with 2-order cosine adjustment, which proved to be the best with the lowest Akaike Information Criterion (AIC) value.

To validate the best fit model, a plot of the cumulative distribution function (CDF) of the detection function and the empirical distribution function (EDF) was generated, and this showed a sufficient fit of the model to the data (see Figure 2). We also used the Cramer-von Mises test (with 100 bootstraps) to further assess the fitness of the top model.

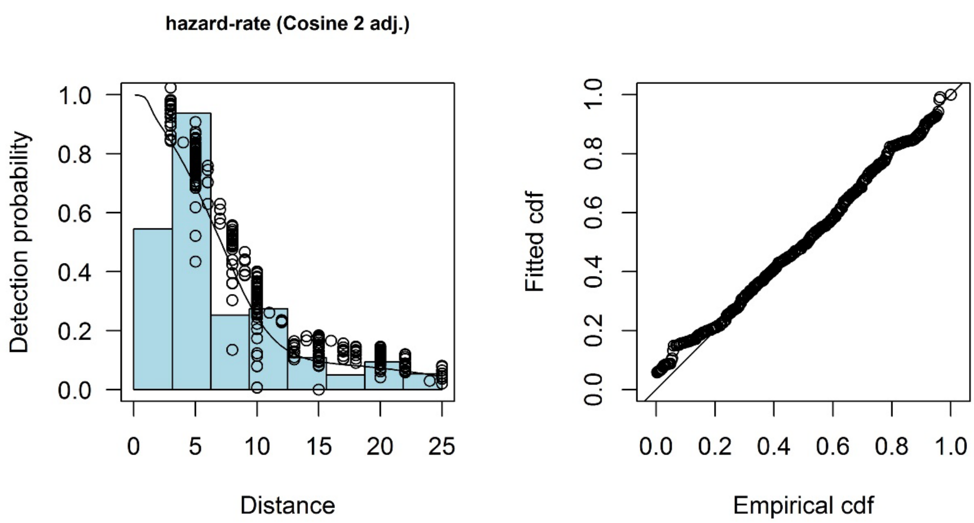

Figure 2. Fitted distance-decay function (Left) and quantile-quantile (qq) plot for goodness-of-fit assessment of the hazard-rate detection function (Right).

2.3.2. Habitat Use and Interspecific Relationships

To examine the yearly, seasonal, and diurnal variations in parrot abundance in the Lobéké National Park, the "mgcv" package was used to fit a Generalized Additive Model (GAM) with a Negative Binomial (nb) distribution and a log link function. The model included year (2022-2024), season, and time of the day as predictors.

We used a GAM with a negative binomial distribution because a graphical assessment revealed substantial evidence of over-dispersion and a non-linear relationship between parrot counts and the time of the day (edf > 1). Ultimately, to capture the complex non-linearity that was associated with the diurnal counts of parrots without causing over-fitting or under-fitting, the non-parametric smoothing function was achieved after optimally pre-defining the basis dimension to k = 150. Model convergence was achieved after 4 iterations, and a small gradient range was obtained (~5.26e−07).

Understanding interspecies relationships is crucial for ecological studies. In this study, Spearman correlations were used to evaluate the relationships between the daily abundance of parrots in the forest clearings and four sympatric bird groups: African green pigeons (*Treron calvus*), Hadada ibis (*Bostrychia hagedash*), potential predators palm-nut vultures (*Gypohierax angolensis*), African harrier hawk (*Polyboroides typus*), African fish eagle (*Haliaeetus vocifer*), and Eleonora falcon (Falco eleonorae).

We used a GAM model with the cyclic cubic spline (cc) to characterize the coexistence in habitat use by parrots and the above sympatric bird groups. By modeling species counts throughout the day, we explore potential overlaps, competition, or avoidance behaviors that could influence their co-occurrence in shared habitats.

3. Results

3.1. Parrot Population Size Estimate

The sampling effort included 49 visits to the Djangui forest clearing, covering approximately a 5-hour duration per day (giving a total of 245 observation hours). The total observation duration per visit was consistent across all surveys; therefore, inclusion of an offset term to account for unequal temporal effort in the GAM model was unnecessary. We encountered an average of 21 flocks per day, with an average flock size per sighting of 167.5 ± 13.2 (SE) individuals. The number of visits grouped on the yearly and seasonal bases yielded the results in **Table 1**.

Table 1. Distribution of survey effort (number of days) across seasons and years during parrot monitoring in Lobéké National Park, Cameroon.

Year	Season	Number of surveyed days
2022	Early dry	7
2022	Late wet	9
2023	Late wet	9
2023	Mid wet	9
2024	Late dry	9
2024	Late wet	6
Total		49

Among the four distance sampling models that were tested for their fitness in estimating the population size of parrots, the hazard-rate (Hr) model with a 2-order cosine adjustment proved to be the best model (**Table 2**). A Cramer-Von Mises test indicated good model fit (= 0.26, p = 0.18; **Figure 2**). Although there was some observer avoidance behavior at closer distances (**Figure 2**), we found some evidence of gradual decay in the detectability of parrots with an increase in radial distance (50 m) from the sampling points (**Figure 2**). Empirical studies support the robustness of distance sampling even when detectability is below one, provided the detection functions are well fitted [30]; hence, this effect is often negligible. The use of the hazard-rate detection functions (with a shoulder) with cosine adjustment also helped to smooth the minor avoidance behavior observed [31].

Based on the Hr model with 2-order cosine, we estimated a total of 2230.2 (CV = 14.9%) different parrot individuals visiting the forest clearings during the course of our study (the absolute abundance of parrots), with a peak sighting of 10,761 individuals per day.

Table 2. Comparison of the candidate detection functions for estimating the population size of the grey parrot in the forest clearings in the Lobéké National Park, Cameroon.

Model	Key function	C-vM (p-Value)	AIC	ΔAIC
Hazard-rate	2 Cosine adjustment	0.26 (0.181)	2140.85	0.00
Hazard-rate	none	0.34 (0.104)	2152.16	11.31
Half-normal	2 Cosine adjustment	0.63 (0.019)	2161.12	20.27
Half-normal	none	2.07 (0,000)	2202.79	61.95

AIC = Akaike's Information Criterion; C-vM = Cramer-von Mises goodness-of-fit.

3.2. Temporal Patterns of Parrot Abundance

There was evidence of yearly, seasonal, and diurnal variation in parrot abundance in the Djangui forest clearing. The results indicate a significant decline in parrot abundance over time, with 2023 showing lower counts in flock size per day $\left(\hat{N} = 104.1\right)$ compared to (2022 $\hat{N} = 226$) ($\hat{\beta}_1$ = −1.15 ± 0.163; P < 0.001; **Table 3** and **Figure 3(A)**) and a steeper decline in 2024 $\left(\hat{N} = 23.7\right)$ ($\hat{\beta}_1$ = −2.40 ± 0.263; P < 0.001; **Table 3** and **Figure 3(A)**).

Table 3. Regression coefficients for yearly and seasonal counts of grey parrots in the Djangui Forest clearing, from the GAM model with negative binomial distribution and seasonal variations in the visitation rates of the grey parrots in the Djangui Forest clearing.

Predictors	Estimate	SE	Z-value	p-value
(Intercept)	4.77	0.08	56.82	<0.001
year: 2023	−1.18	0.16	−7.23	<0.001
year: 2024	−2.40	0.26	−9.14	<0.001
season: Late dry	1.07	0.31	3.51	0.00
season: Late wet	0.42	0.14	2.97	0.003
season: Mid-wet	1.14	0.22	5.25	<0.001
Deviance explained = 52.4%; SE = standard error				

Significant seasonal variations were observed, with parrots visiting the forest clearings in the largest groups during the mid-wet season ($\hat{\beta}_1$ = 1.14 ± 0.217; P <

0.001; Table 3 and Figure 3(C)), followed by the late dry season ($\hat{\beta}_1 = 1.07 \pm 0.305$; P = 0.001; Table 3 and Figure 3(C)) and late wet season ($\hat{\beta}_1 = 0.42 \pm 0.142$; P = 0.003; Table 3 and Figure 3(C)) compared to the early dry season with the lowest count recorded.

Time of day influenced the number of parrots landing in the forest clearing, such that the greatest number of arrivals was expected between 8:30 AM and 9:00 AM (Figure 3(B)).

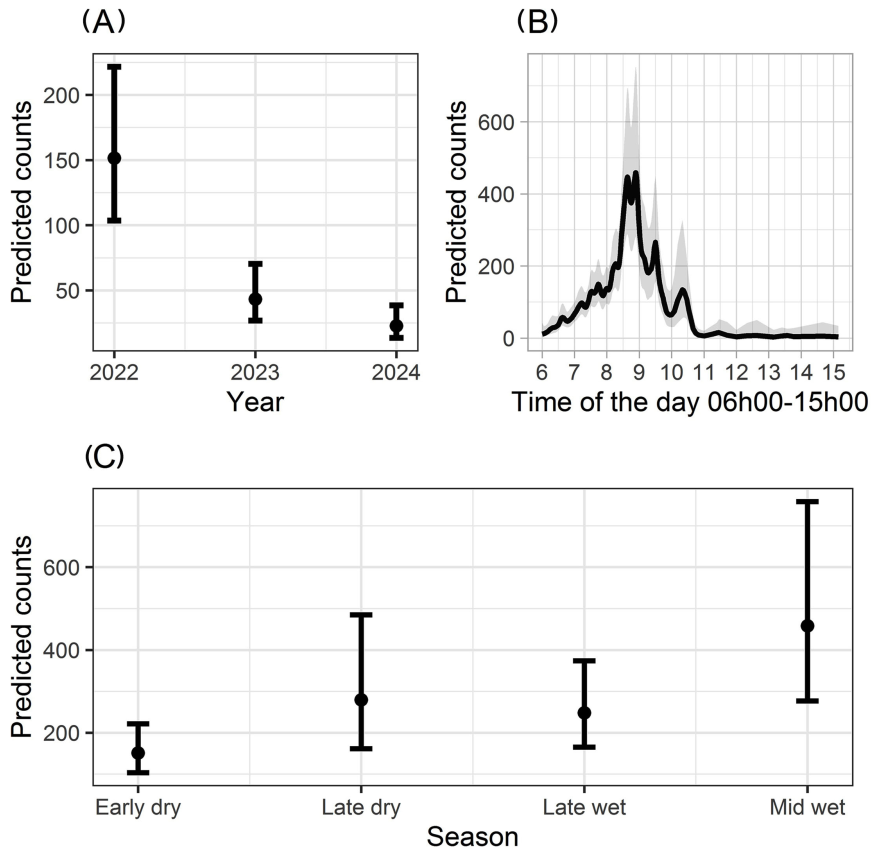

Figure 3. Yearly, seasonal, and diurnal variation of parrot counts at the clearing forest.

3.3. Interspecific Habitat Utilization Patterns of Parrots with Other Species

No interspecific relation was found between palm nut vultures, Hadada ibis, and other potential predators, whose count remained low and uniform relative to parrots throughout the sampling period (from 06:00 h - 15:00 h).

Unlike the other species, African green-pigeon counts tended to be highest in the early morning, while parrots were more abundant in the clearing around mid-morning. Moreover, pigeon abundance tended to be stable during the early morning but dropped quickly, indicating briefer habitat use, unlike the parrots, whose habitat use extended longer into the morning (Figure 4 and Figure 5).

Potential parrot predators (that is, African harrier hawk, African fish eagle, and Eleonora's falcon) tended to increase positively with parrot abundance, although this relationship was not statistically significant ($\alpha = 0.05$, **Figure 4(A)**).

Of the bird and animal species that visited the forest clearing, parrots had the highest counts, with a peak sighting of 10,761 per day compared to the African green pigeons (Nmax = 2650), African fish eagles (Nmax = 27), and dark-capped bulbul (Nmax = 9). Buffalo (Nmax = 10) and the red river hog (Nmax = 9) were among the large mammals with the greatest daily total abundance, while gorillas were sighted twice (Nmax = 3). Sitatunga was the most frequently observed ungulate (Nmax = 7). Also, raptors like Eleonora falcon (Nmax = 4) and scavengers like palm nut vultures (Nmax = 8) were also sighted (**Table 4**).

Table 4. Peak daily sightings of birds and mammals visiting the forest clearing.

Parrots	AHH	BCH	BHH	RRH	Buffalo	BWM	CM
10761	4	11	2	9	10	2	2
DCB	eagle	EF	Egret	GE	Gorilla	Green pigeon	Greenbul
9	27	4	7	21	1	2650	4
HI	HD	Hombill	Magistrate	Obraza	other pigeons	SA	SB
30	12	2	1	1	993	19	4
Sitatunga	SSW	sunbird	P. Vutures	WCS	WTH		
7	1	2	8	4	3		

African Harrier Hawk = AHH, Black-casqued hornbill = BCH, Black-headed Heron = BHH, Red river hog = RRH, Black and white mannikin = BWM, Cassin's Malimbe = CM, Dark-capped Bulbul = DCB, Eleonora's falcon = EF, Great Egret = GE, Hadada Ibis = HI, Hartlaub's Duck = HD, Storks Abdim's = SA, swamp bulbul = SB, Square-tailed Saw-wing = SSW, Palm-nut vulture = P. vulture, woodchat shrike = WCS, White-thighed hornbill = WTH.

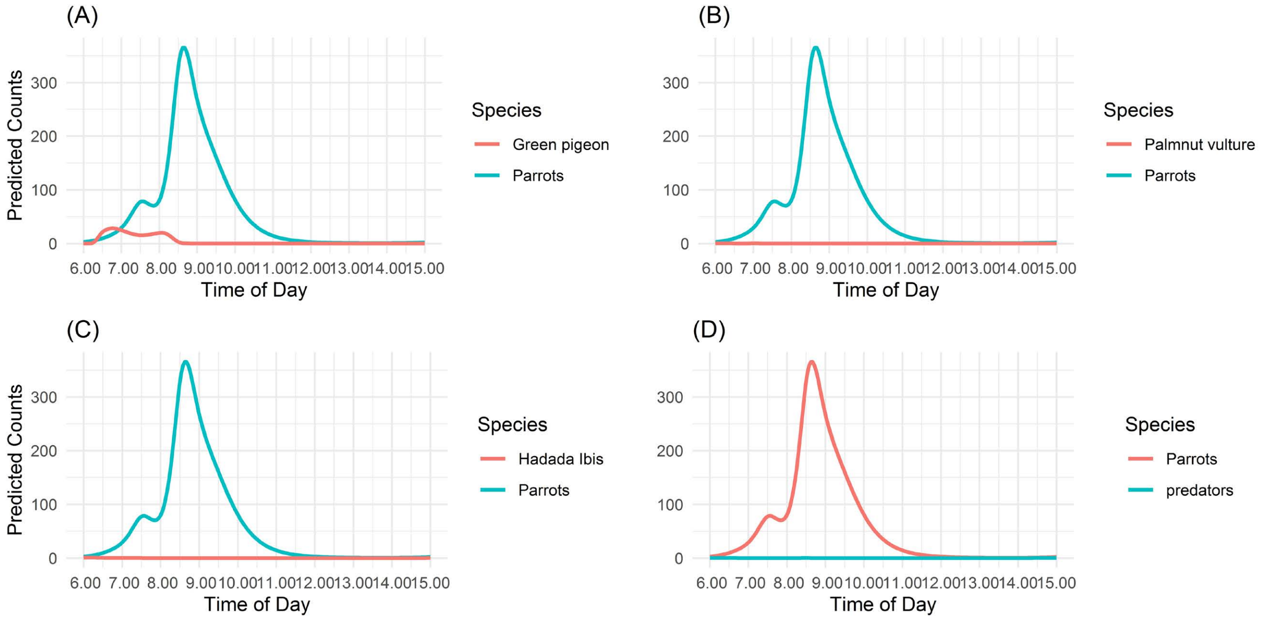

Figure 4. Hourly habitat use patterns of parrots during the day, alongside four sympatric bird groups (A = green pigeon, B = Palmnut vulture, C = Hadada ibis, D = predators: African harrier hawk, eagle, and Eleonora falcon).

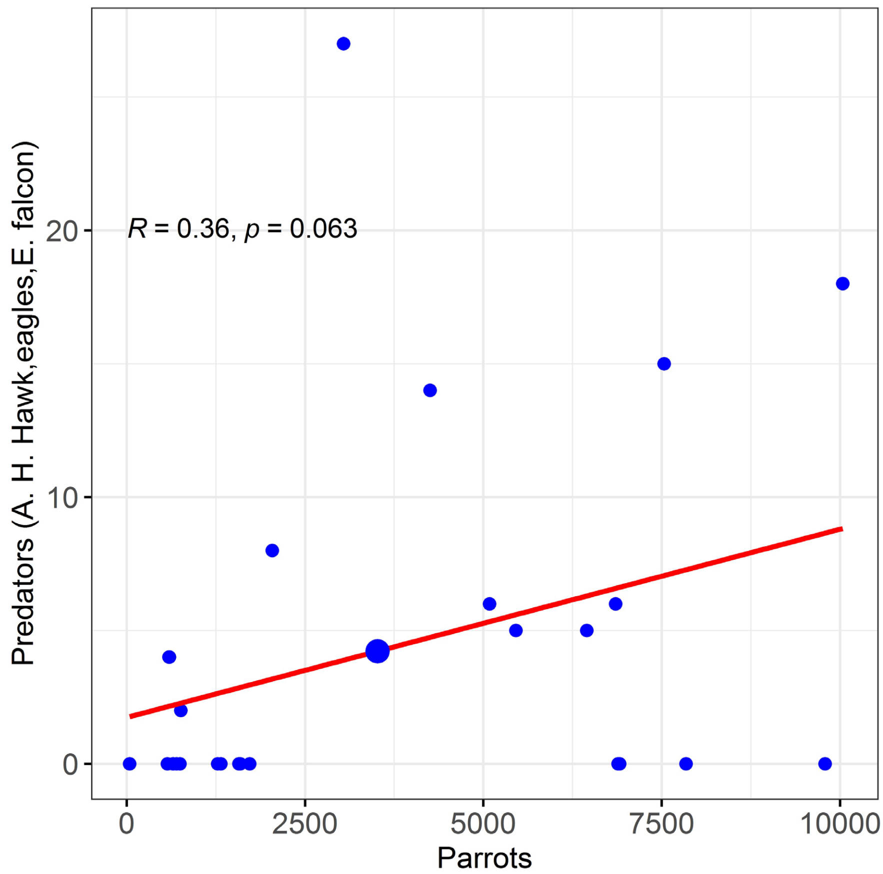

Figure 5. Interspecific abundance correlation (Spearman) across the day between parrots and potential predators (African harrier hawk, eagle, and Eleonora falcon).

4. Discussion

Our study indicates a decline in the population density of grey parrots visiting the Djangui forest clearing over a two-year period (2022 to 2024) and highlights the importance of this clearing for the foraging and roosting ecology of these parrots. The decrease in population size between 2022 and 2024 indicates the need for a change in the management strategy of the park to better favor the grey parrots. Cyclical declines might be expected in a group of living species with abundant predators, as in the case of the grey parrots in this study. That is, predator-prey population cycles can affect year-to-year variation in abundance. Sampling over a greater number of years would enable future research to test this hypothesis. The poaching rate increased, especially during the early dry season (October – December), which coincides with the beginning of annual celebrations; this could be linked to the decrease in population size of the parrots. Future research could investigate other potential drivers of declining parrot abundance, such as climate variations and habitat disturbances.

The parrots tended to follow a daily routine when visiting the forest clearing. They came in from one direction every morning (the Northeast and West direction of the forest clearing). The first parrot(s) to enter the forest clearing every morning determined the tree and position within the clearing that would be used by the rest of the flock. The parrots usually arrived in smaller flocks, and upon arrival, they used soft screeches to determine the position of the other parrots already present in the clearing. They used the morning period between 06:00 AM to 08:00 AM after sunrise to socialize, whereby the parrots perched on trees and used loud screeches to communicate with each other. They also preened their feathers and those of their partners for parrots who arrived in pairs. They mostly used the tallest tree (*Terminalia superba, Triplochiton scleroxylon*, and *Phoenix reclinate* (dominant species in the clearing)), and the tallest branches of these trees, similar to observations by Tamungang *et al.* (2016) on the parrots in Korup National Park. These behaviors may enable individuals to detect and easily escape predators [16] [20]. The parrots moved from one branch to another using their strong beaks instead of using short flights. By 08:00 – 10:00 AM, the parrots were typically at the peak of their activity. They paraded around the forest clearing in a large flock and scouted for possible landing zones or potential danger that could prevent them from landing. During landing, not all of the flock landed; while some landed, the others remained perched on trees as scouts and alerted the group on the ground to the presence of any predator using loud screeches, causing them to fly off.

We discovered that more parrots landed during the late dry season and mid wet season, and they also tended to spend more time in the forest clearing during this period. This could possibly be caused by the lack of food supply and insufficient nutrients in the seeds they consume during this period. They might be trying to compensate for this lack with the nutrients found in the mineral-rich soils of the forest clearing. This observation agrees with those of Bently (1999), who mentioned that parrots feed on soil within clearings to compensate for the nutrients lacking in their seed diet. Fewer parrots came to the clearing during the late rainy season. During this period, the clearings get flooded, which could prevent the parrots from directly landing within the forest clearing. They also arrived late to the clearing the morning after a rainy night because it is usually foggy and cold, and they do not stay for long. A similar pattern of parrot behavior was recorded by Bently (1999) in the Bolo Forest clearing of the Lobéké National Park as well as by Fastré *et al.* (2024) in the forest clearing of Nkuba Conservation Area of the Democratic Republic of Congo. In addition to feeding on the soil, the parrots fed on young stems and leaves of *Pentodron pentandrus* and *Ludwigia abyssinica* for more nutrients, two herb species which are dominant in the forest clearing.

A predator-prey relationship was recorded between parrots and the Eleonora's falcon, the African harrier hawk, and the African fish eagle. These predators came to the clearings early in the morning before large flocks of parrots gathered. They stayed in hiding within the clearing vegetation and mostly attacked when the parrots landed; this made the parrots always be on alert. In order to avoid these predators, the parrots used the African grey pigeons as camouflage during parades and landing, given that large flocks of pigeons also visited the clearing. This survival strategy has also been recorded in parrots of the Democratic Republic of Congo and neo-tropical parrots [9] [20]. Another factor that disturbed the landing pattern of the parrots and caused them to be agitated was the loud sounds produced by the Hadada Ibis and the Black-casqued hornbill when they flew over the clearing. Also, the presence of capturers, which was indicated by the presence of flags (dresses on sticks) within the clearing, caused fewer parrots to land and/or stay within the clearing. This made the parrots change the areas where they landed to areas with fewer disturbances and a lower possibility of being captured. This change in behavior by the parrots could be further explored by future research, as well as other areas visited by the parrots outside of the park. A competitive relationship was observed between the parrots and *Colobus guereza* species, who always chased the parrots away from the landing site.

When disturbed by predators, poachers, or rainfall, the parrots leave the landing area as a flock and perch on trees around the clearing before they start leaving. The parrots tend to leave in the same groups or numbers as they arrived in the morning. Flock formation, communication language, and the flow of information between parrots' flocks within the clearing could be explored by future research. This will shed more light on the behavior of parrots and their cognitive intelligence.

The limitation of data collection for the Djangui forest clearing of the park could be a shortcoming of the findings of this study. To this extent, we propose that data be collected in other clearings visited by the parrots within and outside the Lobéké National Park for a more comparative result, and to provide a broader perspective on the ecological importance of the different clearings to the parrot population. Also, we recommend the incorporation of automated or remote technologies to further improve the accuracy of the data, as well as the inclusion of local community perspectives, especially from the Baka and Bantou ethnic groups near the park, as they hold valuable information on parrot behavior, poaching activities, and forest use patterns that are not captured through scientific data collection methods.

The findings from this study on the variation in habitat utilization and population size estimate of the grey parrots in the Djangui forest clearing could be used by the park management to develop anti-poaching measures (establish stronger patrols and monitoring), especially during the early dry season when poaching is at its peak in this forest clearing. Also, taking into consideration the seasonal behavior of the grey parrots, habitat restoration models prioritizing food and tree resources important to them could be implemented within the park. This could prevent the parrots from moving to areas outside of the park, especially during months of scarcity. Furthermore, the park management could use the findings to develop community engagement strategies to educate the local population on the importance of protecting the parrots. Nationally, the findings of this study could directly inform the National Biodiversity Strategies and Action Plan (NBSAP's) on the importance of the Djangui forest clearing as a key biodiversity hotspot, and provide evidence-based justification on the need for an intervention and adaptive management plan, as well as provide information on species-specific needs and threats, aiding in targeting conservation actions. Regionally, the study offers site-level insights on parrot ecology and threats, especially poaching, which is relevant to wildlife trafficking and mitigation strategies of the Congo Basin Partnership (CBP) and Central African Forest Commission (COMIFAC). It also provides data that can inform a transboundary species conservation plan between the three countries of the Tri-National Conservation Area. Lastly, the findings could inform awareness campaigns under national and regional environmental education programs.

5. Conclusion

The findings of this paper indicate the importance of long-term monitoring of parrot abundance and behavior. It also sheds more light on the importance of the Djangui forest clearing to the ecology of parrots within the Lobéké National Park. Given that the presence of parrots in this site is affected by seasonal and diurnal variations, we suggest that these factors be considered in detail and integrated into the park's conservation strategy. We also suggest that more research be done on the movement patterns of the parrots to know more about their habitat utilization and other parrot hotspots, in order to better protect them and their habitats. Furthermore, future studies could focus on genetic sampling to assess population structure, genetic diversity, and connectivity across the park in particular and the Tri-National area in general. This would also help identify any potential barriers to gene flow due to habitat fragmentation, which is crucial for effective reintroduction or conservation strategies.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

References

[1] Bennun, L., Dranzoa, C. and Pomeroy, D. (1996) The Forest Birds of Kenya and Uganda. *Journal of East African Natural History*, **85**, 23-48. https://doi.org/10.2982/0012-8317(1996)85[23:tfboka]2.0.co;2

[2] Amuno, J.B., Massa, R. and Dranzoa, C. (2007) Abundance, Movements and Habitat Use by African Grey Parrots (*Psittacus erithacus*) in Budongo and Mabira Forest Re-

serves, Uganda. *Ostrich*, **78**, 225-231. https://doi.org/10.2989/ostrich.2007.78.2.17.97

[3] Martin, R.O., Perrin, M.R., Boyes, R.S., Abebe, Y.D., Annorbah, N.D., Asamoah, A., *et al*. (2014) Research and Conservation of the Larger Parrots of Africa and Madagascar: A Review of Knowledge Gaps and Opportunities. *Ostrich*, **85**, 205-233. https://doi.org/10.2989/00306525.2014.948943

[4] Tamungang, S.A., Onabid, M.A., Awa, T. and Balinga, V.S. (2016) Habitat Preferences of the Grey Parrot in Heterogeneous Vegetation Landscapes and Their Conservation Implications. *International Journal of Biodiversity*, **2016**, 1-10. https://doi.org/10.1155/2016/7287563

[5] Dueker, S., Kupsch, D., Bobo, S.K., Heymann, E.W. and Waltert, M. (2020) Congo Grey Parrot *Psittacus erithacus* Densities in Oil Palm Plantation, Agroforestry Mosaic and Protected Forest in Southwest Cameroon. *Bird Conservation International*, **30**, 156-167. https://doi.org/10.1017/s0959270919000194

[6] Blanco, G., Hiraldo, F. and Tella, J.L. (2018) Ecological Functions of Parrots: An Integrative Perspective from Plant Life Cycle to Ecosystem Functioning. *Emu—Austral Ornithology*, **118**, 36-49. https://doi.org/10.1080/01584197.2017.1387031

[7] BirdLife International (2022) Species Factsheet: *Psittacus erithacus*. https://datazone.birdlife.org/search?search=Psittacus%20erithacus

[8] The International Union for the Conservation of Nature (2023) *Psittacus erithacus*. https://www.iucnredlist.org/species/22724813/154428817

[9] Fastré, C., Igwili, B., Van de Perre, F. and van der Hoek, Y. (2024) Visitation Patterns of Endangered Grey Parrots (*Psittacus erithacus*) in a Forest Clearing in the Democratic Republic of the Congo. *Ecology and Evolution*, **14**, e70039. https://doi.org/10.1002/ece3.70039

[10] Dasgupta, S. (2016) International Trade in African Grey Parrots Banned. https://news.mongabay.com/2016/10/international-trade-in-african-grey-parrots-banned/?utm_source

[11] Valle, S., Collar, N.J., Melo, M. and Marsden, S.J. (2020) What Can the Abundance of Grey Parrots on Príncipe Island Tell Us about Large Parrot Conservation? *Journal of Tropical Ecology*, **36**, 293-297. https://doi.org/10.1017/s0266467421000031

[12] CITES (2016) Section 6.2. Consideration Proposals for Amendment of Appendices I and II. Transfer from Appendix II to Appendix I of *Psittacus erithacus* in Accordance with Resolution Conference 9.24. https://cites.org/sites/default/files/eng/cop/17/prop/060216/E-CoP17-Prop-19.pdf

[13] Martin, R.O. (2018) The Wild Bird Trade and African Parrots: Past, Present and Future Challenges. *Ostrich*, **89**, 139-143. https://doi.org/10.2989/00306525.2017.1397787

[14] Annorbah, N.N.D., Collar, N.J. and Marsden, S.J. (2016) Trade and Habitat Change Virtually Eliminate the Grey Parrot *Psittacus erithacus* from Ghana. Ibis, **158**, 82-91. https://doi.org/10.1111/ibi.12332

[15] Bently, C.S. (1999) Soil Eating Grey Parrots in Cameroon: An Answer to Mineral Deficiencies or Toxins in the Diet? Master's Thesis, University of Arizona.

[16] Tamungang, S.A. and Cheke, R.A. (2012) Population Status and Management Plan of the African Grey Parrot *Psittacus erithacus* in Cameroon. A CITES Report. https://cites.org/sites/default/files/eng/com/sc/62/inf/E62i-14.pdf

[17] Ngenyi, A., Nzooh, Z. and Usongo, L. (2003) The Impact of Capture and Trade in African Grey Parrot Populations (*Psittacus erithacus*). *Journal of Cameroon Academy Science*, **3**, 11-16.

[18] Tamungang, S.A., Cheke, R.A., Mofor, G.Z., Tamungang, R.N. and Oben, F.T. (2014) Conservation Concern for the Deteriorating Geographical Range of the Grey Parrot in Cameroon. *International Journal of Ecology*, **2014**, 1-15. https://doi.org/10.1155/2014/753294

[19] Gilardi, J.D., Duffey, S.S., Munn, C.A. and Tell, L.A. (1999) Biochemical Functions of Geophagy in Parrots: Detoxification of Dietary Toxins and Cytoprotective Effects. *Journal of Chemical Ecology*, **25**, 897-922. https://doi.org/10.1023/a:1020857120217

[20] Brightsmith, D.J. and Villalobos, E.M. (2011) Parrot Behavior at a Peruvian Clay Lick. *The Wilson Journal of Ornithology*, **123**, 595-602. https://doi.org/10.1676/09-109.1

[21] Griffiths, B.M., Hansbrough, G., Griffiths, L.G., Valderrama, D. and Gilmore, M.P. (2024) Drivers of Geophagy of Large-Bodied Amazonian Herbivorous and Frugivorous Mammals. *Scientific Reports*, **14**, Article No. 29707. https://doi.org/10.1038/s41598-024-80237-0

[22] Tamungang, S.A. and Ajayi, S.S. (2003) Diversity of Food of the Grey Parrot Psittacus Erithacus in Korup National Park, Cameroon. *Bulletin of the African Bird Club*, **10**, 33-36. https://doi.org/10.5962/p.309683

[23] Tieguhong, J.C. and Nkamgnia, E.M. (2012) Household Dependence on Forests around Lobeke National Park, Cameroon. *International Forestry Review*, **14**, 196-212. https://doi.org/10.1505/146554812800923426

[24] Ginath Yuh, Y., N'Goran, P.K., Dongmo, Z.N., Tracz, W., Tangwa, E., Agunbiade, M., *et al.* (2020) Mapping Suitable Great Ape Habitat in and around the Lobéké National Park, South-East Cameroon. *Ecology and Evolution*, **10**, 14282-14299. https://doi.org/10.1002/ece3.7027

[25] Temgoua, L.F., Momo Solefack, M.C., Mevoungou, M. and Mengamenya, A. (2018) Caractérisation de la végétation des clairières sur sol hydromorphe du Parc National de Lobéké, Est-Cameroun. *International Journal of Biological and Chemical Sciences*, **12**, 1364-1380. https://doi.org/10.4314/ijbcs.v12i3.24

[26] World Wildlife Fund for Nature (2021) Integrated Management of Cameroon's Forest Landscape in the Congo Basin: Environmental and Social Management Framework. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/909d8w9ext_ESMF_Cameroon_CGES_GEF_7_June_3_Final.pdf#page=37&zoom=100,72,154

[27] Marolla, F., Marsden, S.J., Boitani, L. and Valle, S. (2016) Testing Long-Watch Counts as a Surrogate for Density Estimates to Monitor Parrot Populations. PhD Studies Department of Arctic and Marine Biology, UiT the Arctic University of Norway.

[28] Marsden, S.J. (1999) Estimation of Parrot and Hornbill Densities Using a Point Count Distance Sampling Method. *Ibis*, **141**, 327-390. https://doi.org/10.1111/j.1474-919x.1999.tb04405.x

[29] Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. (2001) Introduction to Distance Sampling: Estimating Abundance of Biological Population. Oxford University Press.

[30] Gonzalez, R.P., Thomas, L. and Tiago, A.M. (2017) Evaluation of Analysis of Distance Sampling Data: A Simulation Study. *Journal of Environmental and Ecological Statistics*, **24**, 399-414.

[31] Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. (1993) Distance Sampling: Estimating Abundance of Biological Populations. *Biometrics*, **50**, 891-892.